# SEMIARID PRECIPITATION FREQUENCY STUDY

Update of *Technical Paper No. 40, Technical Paper No. 49* and *NOAA Atlas 2*

Twenty-first Progress Report
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Hydrometeorological Design Studies Center
Hydrology Laboratory

Office of Hydrologic Development
U.S. National Weather Service
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# SEMIARID
# PRECIPITATION FREQUENCY STUDY

Update of *Technical Paper No. 40, Technical Paper No. 49* and *NOAA Atlas 2*

## 1. Introduction.

The Hydrometeorological Design Studies Center (HDSC), Hydrology Laboratory, Office of Hydrologic Development, U.S. National Weather Service is updating its precipitation frequency estimates for the Semiarid Southwestern United States. Current precipitation frequency estimates for the Semiarid region are contained in *Technical Paper No. 40* "Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years" (Hershfield 1961), *Technical Paper No. 49* "Two- to ten-day precipitation for return periods of 2 to 100 years in the contiguous United States" (Miller et al 1964) and *NOAA Atlas 2* “Precipitation-Frequency Atlas of the Western United States.” The new study includes collecting data and performing quality control, compiling and formatting datasets for analyses, selecting applicable frequency distributions and fitting techniques, analyzing data, mapping and preparing reports and other documentation.

The study will determine annual all-season precipitation frequencies for durations from 5 minutes to 60 days, for return periods from 2 to 1000 years. The study will review and process all available rainfall data for the Semiarid study area and use accepted statistical methods. In particular, the Semiarid Study is the pilot study in which decisions regarding the methods and format are being made that will affect subsequent studies. The study results will be published as Volumes of *NOAA Atlas 14* on the internet using web pages with the additional ability to download digital files.

The Semiarid study will produce estimates for 4 states completely, Arizona, Nevada, New Mexico, and Utah, and southeastern California. Additional data from 7 bordering states and Mexico (Figure 1) are included for continuity across state borders. The core and border areas and regional groups for long duration (24-hour through 60-day) analyses are shown in Figure 1. Regional groups for short duration (60-minute through 12-hour) analyses are shown in Figure 2.

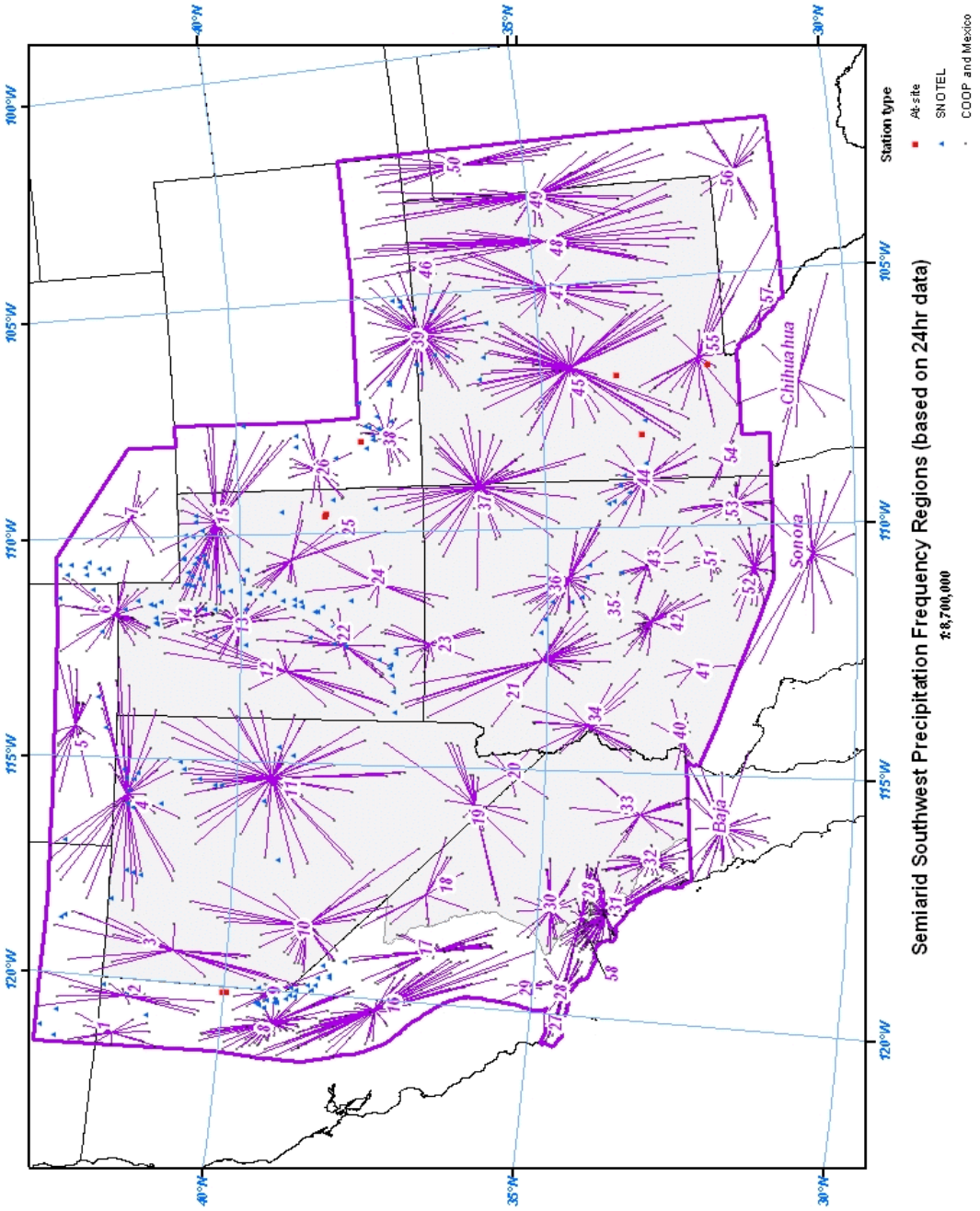


Figure 1. Semiarid Precipitation Frequency study area and new regional groups for 24-hour and longer duration values.

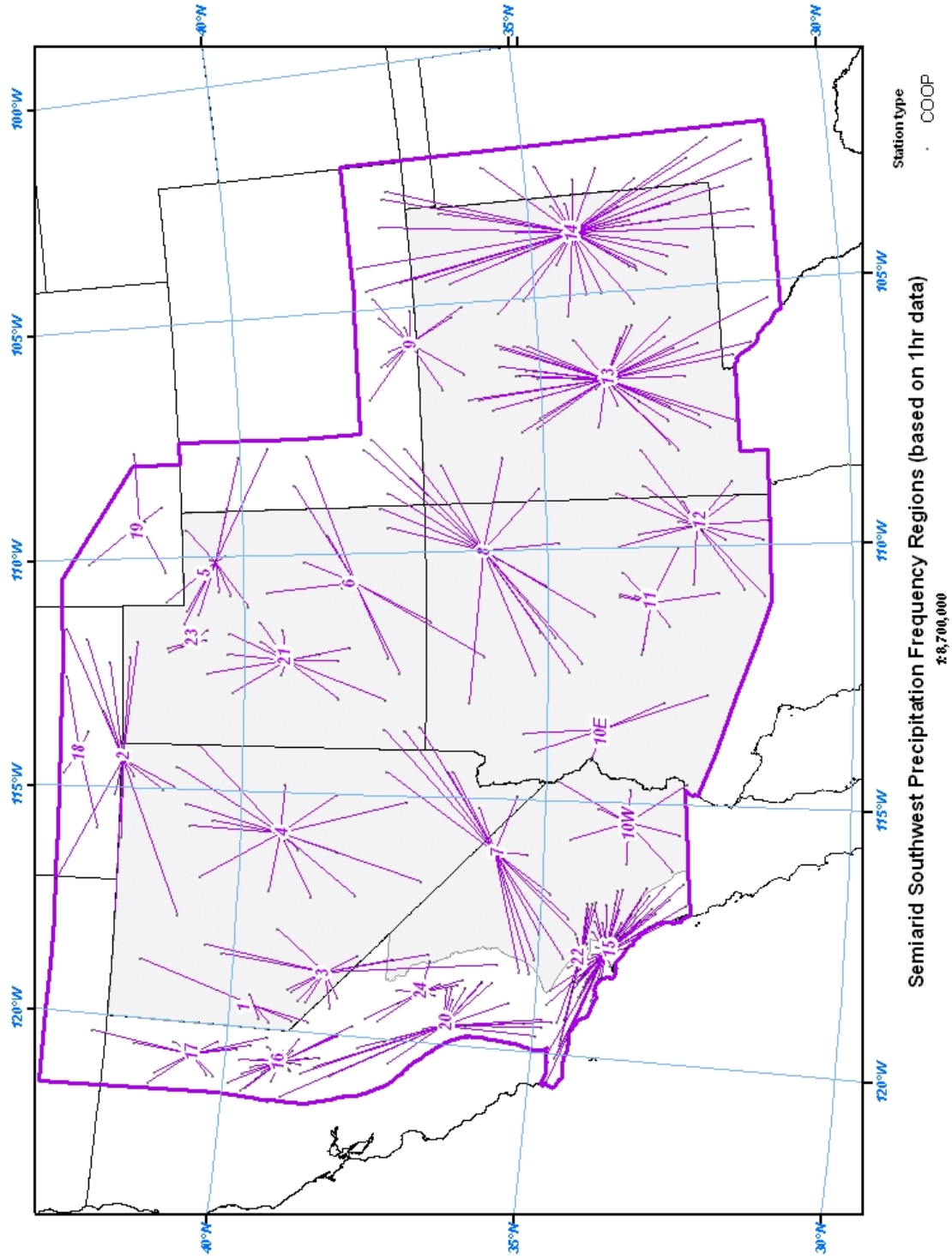


Figure 2. Semiarid Precipitation Frequency regional groups for 12-hour and shorter duration values.

## 2. Highlights.

All data collection and quality control is complete. SNOTEL (SNOpack TELemetry) daily data were compiled and quality controlled. Extreme daily values and L-moment results from Mexico stations were inspected to ensure quality. As a result some re-grouping of Mexico stations occurred. Annual maximum series for long durations (2-day through 60-day) were extracted and quality controlled based on heterogeneity, discordancy and real data check. Additional information is provided in Section 4.1, Data Collection and Quality Control.

All L-moment analyses and regionalization are complete for all durations 5-minute through 60-day. Since 24-hour precipitation frequency estimates are the most stable and abundant, the original 24 regions of the Semiarid study were subdivided based on the 24-hour analysis results into 58 regions. During the subdivision process, heterogeneous regions were re-grouped into homogeneous regions based on climatology, topography, and a real data check. Long duration L-moment results based on 58 regions were closely examined to validate estimates in heterogeneous regions. Short duration (60-minute to 12-hour) L-moment analyses were based on the original 24 regions due to the sparsity of data in the study area. N-minute durations (5-minute to 30-minute) were based on 6 regions because there are even fewer n-minute stations. Ratios of n-minute to 60-minute estimates were applied to calculate precipitation frequency estimates for all n-minute durations at all hourly stations. Additional information is provided in Section 4.2, L-moment Analysis and Regionalization.

Software was developed to calculate confidence intervals for all precipitation frequency estimates for durations, and the intervals were computed. Software was also developed to check the internal consistency of estimates and confidence intervals across durations. Practical adjustments using ratios with shorter durations were made where appropriate to mitigate any inconsistencies. Additional information is provided in Section 4.2, L-moment Analysis and Regionalization.

On June 26, 2002 HDSC delivered the point mean annual maxima (a.k.a. “index flood”) values to the Spatial Climate Analysis Service (SCAS) at Oregon State University. The SCAS will use PRISM to spatially interpolate the values to grids, which will later be used by HDSC to derive the precipitation frequency maps. Additional information is provided in Section 4.3, Spatial Interpolation.

Several changes were made to the password protected Precipitation Frequency Data Server (PFDS) this quarter. Most important was the added functionality of selecting an observing site (either via a map or list). This added functionality allowed for a peer review of Semiarid point precipitation frequency estimates. Additional information is provided in Section 4.4, Precipitation Frequency Data Server.

We decided to conduct two separate peer reviews rather than a review of all

deliverables at once. The first review will be of the point precipitation frequency estimates. The second review will be of the spatially interpolated grids. For the Semiarid Project, the peer review of the point precipitation frequency estimates began on June 27, 2002 and will conclude on July 26, 2002. Additional information is provided in Section 4.5, Peer Review.

Development of depth-area-duration (DAD) reduction relationships for areas from 10 to 400 square miles continues. Data has been gathered and quality controlled for 8 dense-area-networks. Software development has begun. Additional information is provided in Section 4.6, Depth Area Duration Study.

We decided to exclusively publish the study results electronically to avoid printing expenses and to publish monthly patterns of extreme precipitation but not compute monthly frequency estimates. Additional information is provided in Section 5, Issues.

## 3. Status.

### 3.1 Project Task List.

The following checklist shows the components of each task and an estimate of the percent completed per task. Past status reports should also be referenced for additional information.

Semiarid study checklist [estimated percent complete]:

Data Collection, Formatting and Quality Control [100%]:

- Multi-day
- Daily
- Hourly
- 15-minute
- N-minute

SNOTEL, Mexico and long durations were updated and quality controlled. All datasets (5-minute through 60-day) are complete.

L-Moment Analysis/Frequency Distribution for 5 minute to 60 days and 2 to 1000 years [100%]:

- Multi-day
- Daily
- Hourly
- 15-minute
- N-minute

Annual maximum series were extracted for all durations (5-minute through 60-day). L-moment analysis is complete for all data (5-minute through 60-day). 24-hour and longer duration results led to the regrouping of stations into 58 regions. Discordancy, heterogeneity, and real data checks are complete for all durations (60-minute through 60-day). N-minute precipitation frequency estimates (5-minute through 30-minute) are calculated.

Spatial Interpolation [0%]

- Create grids of interpolated means for each duration (1-hr, 2-hr, 3-hr, 12-hr, 24-hr, 48-hr, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, 60-day) using PRISM
- Subject grids of interpolated means to external review

Mean annual maxima values were calculated by HDSC and delivered to the Spatial Climate Analysis Service (SCAS). SCAS will use PRISM (Parameter-elevation Regressions on Independent Slopes Model) to spatially interpolate the mean annual maxima values (a.k.a. “index flood”) to grids. Draft grids will be critically reviewed by peers. At HDSC, “index flood” grids will be multiplied by appropriate regional growth factor (RGF) grid to derive each precipitation frequency grid.

Peer Reviews [25%]

- Lead review of point precipitation frequency estimates
- Lead review of spatial interpolation grids

The review of point precipitation frequency estimates was initiated on June 26, 2002. It will conclude on July 26, 2002 at which time HDSC will respond to reviewer comments.

Precipitation Frequency Maps [5%]

- Create smoothed regional growth factor (RGF) grids using GRASS
- Multiply appropriate RGF and distributed mean grids to produce precipitation frequency grids for durations 1-hr, 2-hr, 3-hr, 12-hr, 24-hr, 48-hr, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, and 60-day at return frequencies of 2-yr, 5-yr, 10-yr, 25-yr, 50-yr, 100-yr, 200-yr, 500-yr, and 1000-yr for a total of 162 maps
- Apply study-wide conversion factor to the 60-minute precipitation frequency grids to calculate the n-minute (5-, 10-, 15-, and 30-minute) grids
- Perform internal consistency checks (comparing rasters of sequential duration and frequency)

Data Trend Analysis [20%]

- Analyze linear trends in annual maxima and variance over time
- Analyze shift in means of annual maxima between two time periods (i.e., test the equality of 2 population distribution means)

An updated trend analysis of 1-day annual maximum series has begun. The analysis includes parametric and non-parametric statistical tests to discern if any linear trend exists in the data and if any shift in mean between sequential segments of data records has occurred.

Temporal Distributions of Extreme Rainfall [100%]

- assemble hourly data by quartile of greatest precipitation amount and convert to cumulative rainfall amounts for each region
- sort, average, and plot time distribution of hourly maximum and median events for different climatological regions and seasons

Temporal distributions of extreme rainfall in the Semiarid study area have been examined. The results will be presented in graphs representative of 2 different climatological regions and seasons. These graphs and accompanying tables are complete.

Deliverables [50%]

- Prepare data for web delivery
- Prepare documentation for web delivery
- Write hard copy of Final Report
- Publish hard copy of Final Report

The Semiarid study station-specific results have been made available on the password-

protected Precipitation Frequency Data Server for peer review. Once mapping is complete and internally reviewed, the spatially interpolated grids will also be available for peer review. The Precipitation Frequency Data Server displays precipitation frequency values and intensity-duration-frequency curves and tables. Additional station-specific functionality has been added to facilitate the review of point estimates.

Additional Work:

Spatial Relations (Depth-Area-Duration Study) [25%]

- Obtain hourly data from dense-area reporting networks
- QC and format data from dense networks
- Compute maximum and average annual areal depth for each duration from stations from each network
- Compute ratio of maximum to average depth for all durations and networks and plot
- Prepare curves of best fit (depth-area curves) for each duration and network

Depth Area Duration (DAD) reductions for areas from 10 to 400 square miles are being updated for the entire United States and will be presented in a separate volume of NOAA Atlas 14.

## 4. Progress in this Reporting Period.

### 4.1 Data Collection and Quality Control.

All data collection and quality control is complete.

#### 4.1.1 SNOTEL Daily Data.

SNOwpack TELemetry (SNOTEL) daily data were revisited in preparation for spatial interpolation. Having values at higher elevations will reduce uncertainties in PRISM calculations. SNOTEL data at all available stations were downloaded from the Western Regional Climate Center web-site (http://www.wrcc.dri.edu/cgi-bin/snoX_graphX.pl). The data was formatted and the annual maximum series were extracted. Extreme values that exceeded the 50yr24hr estimate of NOAA Atlas 2 were quality controlled by comparing the values with nearby stations for the given event. Table 1 below shows the number of SNOTEL stations with at least 15 years of data that will be used in our analysis.

Table 1. Number of SNOTEL stations in each state with at least 15 years of data.

| **State** | **# stations** (≥15 yrs data) |
|---|---|
| Arizona | 13 |
| California | 24 |
| Colorado | 21 |
| Idaho | 7 |
| Nevada | 26 |
| New Mexico | 12 |
| Oregon | 5 |
| Utah | 69 |
| Wyoming | 9 |
| **Total** | **186** |

Means for the 24-hr, 48-hour, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, and 60-day durations were extracted. Mean values will be used in the spatial interpolation by PRISM but the stations will not be used in the calculation of the shape of the distribution functions due to the poor quality and quantity of the data.

4.1.2 Mexico Daily Data.

Mexico daily data were revisited in preparation for spatial interpolation. The maximum record length of this data is 15 years. Even though these stations do not have at least 20 years of record, they provide information that will be used during the spatial interpolation to provide continuity across the southern border of the core area. Annual maximum series were extracted from the Mexico data using 13 years as the minimum years of record so that a reasonable number of stations could be included. The number of stations in each of the Mexico regions in shown in Table 2.

Table 2. Number of Mexico stations in each region with at least 13 years of data.

| **State** | **# stations** (≥13 yrs data) |
|---|---|
| Baja | 30 |
| Sonora | 20 |
| Chihuahua | 10 |
| **Total** | **60** |

Extreme values greater than 4 inches were quality controlled for all 3 Mexico regions. The annual maximum series were extracted for 24-hr, 48-hr, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, and 60-day durations. L-moment analysis indicated that Sonora was heterogeneous. Therefore, the regions were modified by moving 4 stations from Sonora to Baja based on geographical location, climatology, and statistical results creating homogeneous regions for all durations. The mean values were extracted, formatted and sent to SCAS.

4.1.3 Long Duration Data (48-hour trough 60-day)

The long durations of all eligible stations (with 20 years or more of data) were extracted. They were quality controlled by selecting a representative duration, typically the 10-day duration, based on L-moment results. Discordant stations for this duration were inspected. The highest maximums in each region were also examined. Values that exceeded the 100-yr precipitation frequency estimate were quality controlled in the Real Data Check. Methods to examine suspicious data include, but are not limited to, comparing with other data sources (e.g., archived NOAA Climatological Data), comparing with the data of other stations in the vicinity. Because most extreme events for longer durations (20-day through 60-day) are dominated by 10-day accumulations in the semiarid area, QC of this duration was sufficient quality control. Similarly, most extreme 1-day events dominate the 2- to 7-day events and 1-day events have already been excruciatingly quality controlled. Quality control of long durations is complete.

## 4.2 L-moment Analysis and Regionalization.

### 4.2.1 L-moment Results for 24-hour Duration.

Since 24-hour precipitation frequency estimates are the most stable and abundant and have been through excruciating quality controlled, the original 24 regions of the Semiarid study were subdivided into 58 regions based on L-moment analysis of 24-hour data. During the subdivision process, heterogeneous regions were re-grouped into homogeneous regions based on climatology, topography, Real Data Check and statistical results. In Real Data Check, large discrepancies between 100-yr estimate and maximum observed rainfall are carefully examined.

The Generalized Extreme Value (GEV) distribution is the best-fit distribution for the Semiarid study area for 24-hour values.

The 2-yr and 100-yr quantiles were carefully examined for the entire study area to ensure continuity, particularly from region to region. Comparisons between our results and NOAA Atlas 2 (NA2) have been made and differences have been carefully considered. Reasons for differences between our current precipitation frequency estimates and those from NA2 include longer records of data, more stations, and greater effectiveness of new statistical procedures. Preliminary inspection showed the largest differences are in mountain areas where the NA2 analysis did not have stations.

Table 3 below details the number of stations in each of the new 58 regions based the 24-hour duration (also see Figure 1). The regions were generally numbered sequentially west to east such that region 1 is the most northwesterly region. Six stations, or small groups of stations, were candidates for “at-site” analysis. These stations exhibited characteristics that did not agree with the regional characteristics. A1 through A6 include these stations.

Table 3. Number of stations in final 58 regions based on 24-hour duration.

| Region | total # of Stations | # daily stns | # hourly stns |
|---|---|---|---|
| 1 | 13 | 11 | 2 |
| 2 | 18 | 13 | 5 |
| 3 | 24 | 20 | 4 |
| 4 | 44 | 35 | 9 |
| 5 | 28 | 25 | 3 |
| 6 | 41 | 35 | 6 |
| 7 | 13 | 10 | 3 |
| 8 | 72 | 45 | 27 |
| 9 | 17 | 11 | 6 |
| 10 | 36 | 25 | 11 |
| 11 | 63 | 48 | 15 |
| 12 | 21 | 17 | 4 |
| 13 | 37 | 31 | 6 |
| 14 | 35 | 28 | 7 |
| 15 | 59 | 45 | 14 |
| 16 | 68 | 57 | 11 |
| 17 | 44 | 27 | 17 |
| 18 | 12 | 9 | 3 |
| 19 | 21 | 16 | 5 |
| 20 | 8 | 7 | 1 |
| 21 | 42 | 36 | 6 |
| 22 | 32 | 28 | 4 |
| 23 | 20 | 17 | 3 |
| 24 | 15 | 12 | 3 |
| 25 | 20 | 19 | 1 |
| 26 | 19 | 17 | 2 |
| 27 | 23 | 14 | 9 |
| 28 | 48 | 29 | 19 |
| 29 | 11 | 6 | 5 |
| 30 | 31 | 22 | 9 |
| 31 | 121 | 80 | 41 |
| 32 | 46 | 32 | 14 |
| 33 | 23 | 17 | 6 |
| 34 | 27 | 21 | 6 |
| 35 | 6 | 6 | 0 |
| 36 | 40 | 36 | 4 |
| 37 | 58 | 51 | 7 |
| 38 | 21 | 18 | 3 |
| 39 | 68 | 55 | 13 |
| 40 | 12 | 11 | 1 |
| 41 | 8 | 6 | 2 |
| 42 | 39 | 36 | 3 |
| 43 | 21 | 15 | 6 |
| 44 | 31 | 26 | 5 |
| 45 | 88 | 61 | 27 |
| 46 | 6 | 4 | 2 |
| 47 | 37 | 29 | 8 |
| 48 | 45 | 33 | 12 |
| 49 | 53 | 42 | 11 |
| 50 | 26 | 23 | 3 |
| 51 | 15 | 13 | 2 |
| 52 | 29 | 27 | 2 |
| 53 | 31 | 25 | 6 |
| 54 | 8 | 7 | 1 |
| 55 | 31 | 22 | 9 |
| 56 | 27 | 19 | 8 |
| 57 | 9 | 7 | 2 |
| 58 | 5 | 4 | 1 |
| A1 | 02-6524 | 1 | 0 |
| A2 | 02-0818 | 1 | 1 |
| A3 | 29-1138 | 1 | 0 |
| A4 | 29-8535 | 1 | 0 |
| A5 | 42-5733, 42-0336, 42-0336H | 2 | 1 |
| A6 | 04-2504, 04-2506 | 2 | 0 |

### 4.2.2 L-moment Results for Long Durations (48-hour to 60-day).

The daily stations in each of the regions listed in Table 3 comprise the long duration dataset. 29% of all long duration results of all regions had high heterogeneity (H1) factors. H1 is based on the L-coefficient-of-variation (L-CV) as described in Hosking and Wallis (1997). A threshold of 2 is reasonable for the heterogeneity test, especially for precipitation data. Therefore, a value greater than 2 (H1>2) indicates heterogeneity, rather than homogeneity (H1<2). Long duration L-moment results where H1 was greater than 2 were closely examined to validate estimates. In most cases, one or several data points or stations were driving the heterogeneity. In these regions H1 decreased significantly when L-moments were run while omitting the offending stations while the 100-yr precipitation frequency estimates and Regional Growth Factors changed by 5% or less. Therefore, the high heterogeneity values in these regions were accepted without modifying the regions themselves.

Some minor shifting of stations occurred to resolve two heterogeneous regions based on long duration results. A subregion, now called region 58, was formed from 5 stations in region 31. Also, two stations in region 2 were analyzed as a small “at-site” region. These changes were also applied to the 24-hour duration and are therefore reflected in Table 3.

The Generalized Extreme Value (GEV) distribution is the best-fit distribution for the Semiarid study area for 48-hour and longer duration values.

### 4.2.3 L-moment Results for Short Durations (60-minute to 12-hour).

L-moments for 60-minute, 2-hour, 3-hour, 6-hour, and 12-hour were calculated using the original 24 Semiarid regions due to sparsity of data in the study area (see Figure 2). The results show less heterogeneity than the long durations. As with the long durations, high heterogeneity factors of the regions (H1>2) could be pin-pointed to specific data points or stations in most cases. It was decided to accept those heterogeneous regions without modification since most of the heterogeneity was due to the limited number of stations or the low years of record of many of those stations. Only region 10 was subdivided into 10East and 10West to resolve heterogeneity issues. Table 4 lists the number of hourly stations in each region.

The Generalized Extreme Value (GEV) distribution is the best-fit distribution for the Semiarid study area for 60-minute to 12-hour durations.

Table 4. Number of stations in final 25 regions based on hourly data.

| Region | # of hourly stns |
|---|---|
| 1 | 6 |
| 2 | 14 |
| 3 | 14 |
| 4 | 16 |
| 5 | 12 |
| 6 | 10 |
| 7 | 16 |
| 8 | 21 |
| 9 | 12 |
| 10E | 6 |
| 10W | 9 |
| 11 | 10 |
| 12 | 17 |
| 13 | 40 |
| 14 | 45 |
| 15 | 65 |
| 16 | 25 |
| 17 | 12 |
| 18 | 4 |
| 19 | 5 |
| 20 | 22 |
| 21 | 15 |
| 22 | 19 |
| 23 | 7 |
| 24 | 11 |

### 4.2.4 L-moment Results for N-minute Durations (5-minute to 30-minute).

N-minute durations were based on 6 regions because there are very few available stations. One station was anomalous and was analyzed as an at-site station. N-minute to 60-minute ratios were derived from co-located hourly and n-minute stations. The ratios were calculated on a regional basis, then averaged to form a global n-minute to 60-minute ratio. This ratio was applied to calculate precipitation frequency estimates for all n-minute durations (5-, 10-, 15-, and 30-minute) at all hourly stations in study area.

The best fit distribution was GEV for the 5-, 10-, and 15-minute durations. GNO was the best fit distribution for the 30-minute duration.

### 4.2.5 Development of Additional Software.

Software was developed to calculate confidence intervals associated with each precipitation frequency estimate at all durations. These intervals are provided as an upper bound and a lower bound at the 90% confidence level. For n-minute data, 60-minute mean and 60-minute confidence intervals are applied as ratios to compute the upper and lower bounds for n-minute estimates. All confidence intervals were calculated and included in the peer review.

Software was written to provide internal consistency to the precipitation frequency estimates across durations. Cases where a shorter duration has an estimate that is higher than the next longer duration (e.g., 2-hr = 1.9 and 3-hr = 1.5) were identified. These inconsistencies are not realistic and are an artifact of the data. The calculation of precipitation frequency estimates uses the mean annual maximum and the L-skewness of the data. Inconsistencies result when durations have similar means but the shorter duration has higher skewness. Practical adjustments using ratios with the previous durations were made where appropriate to mitigate such inconsistencies. This type of adjustment was also made for inconsistencies in confidence intervals.

## 4.3 Spatial Interpolation.

On June 26, 2002 HDSC delivered the Semiarid point mean annual maximum (a.k.a. “index flood”) values to the Spatial Climate Analysis Service (SCAS) at Oregon State University. SCAS will use PRISM (Parameter-elevation Regressions on Independent Slopes Model) to spatially interpolate the mean annual maximum values to grids at a resolution of 30-seconds. HDSC will then use the “index flood” grids (one per duration) to derive each of the precipitation frequency grids (5-minute through 6-day and 2-year through 1000-year). A kick-off meeting/conference call in early July will mark the official initiation of this task.

## 4.4 Precipitation Frequency Data Server.

Several changes were made to the password protected Precipitation Frequency Data Server (PFDS) this quarter. Functionality to extract data for a specific observing site was added. A user can now select an observing site from a pull-down list or by simply clicking on it from a map. This has allowed peer-reviewers to evaluate the point precipitation frequency estimates for the Semiarid southwest study before the spatial maps are complete. Since the maps are not complete, however, some of the PFDS functionality (i.e. picking any location on the map and determining areal estimates), was turned off for the review.

In order to accommodate the observing site selection option, the PFDS interface changed slightly, as did the output page. Changes include, but are not limited to: output duration changed from 10-days to 60-days, return periods extended to 1000-years, added reference maps to show surrounding area to output page, removed the seasonality option, added a link to the National Climatic Data Center (NCDC) showing nearby observing sites and sources of climate data, and made the background of the state maps color-shaded elevation (instead of a black and white hill shade).

After these changes were completed, along with significant behind the scenes programming modifications and the population of the PFDS with the final semiarid all-season data (5-minute through 6-day and 2-year through 1000-year), an internal review commenced. After all of the review comments were addressed, a public peer-review of the PFDS and the Semiarid point data was initiated.

## 4.5 Peer Review.

It was decided to lead two separate peer reviews rather than a review of all deliverables at once. The first review will be of the point precipitation frequency estimates. The second review will be of the spatially interpolated grids.

A peer review of the Semiarid point precipitation frequency estimates began on June 27, 2002 and will conclude on July 26, 2002. The review includes point frequency estimates and associated confidence intervals for all durations (5-minute to 60-day) and all return frequencies (2-year to 1000-year). It covers all stations, even those outside the core area that will be the focus of NOAA Atlas 14. The core study includes Arizona, New Mexico, Nevada, Utah and southeastern California. The purpose for the non-core area is to provide continuous data across the exterior study area border. Comments pertaining to data in non-core areas will be addressed according to their influence to the core study area. The reviewers have also been asked to critically comment on the new Internet-based Precipitation Frequency Data Server (PFDS).

## 4.4 Spatial Relations (Depth Area Duration Study).

During the second quarter of 2002, processing of data continued for study areas being used to develop depth-area-duration (DAD) relationships applicable to basins ranging in area from 10 to 400 square miles. Currently, 12 study areas are being considered (See Table 5). The areas were selected based on the following criteria: 1) Availability of a dense area of hourly reporting rain gauges; 2) location, as there is a desire to include as many geographically and orographically diverse study areas of the US as possible; and 3) minimum period of record for reporting gauges (at least 15 years of record).

Data has been collected and prepared as shown in Table 5. Also, if additional dense-area-networks are identified, they will be added after the current software development phase of the projected is completed.

Table 5. Dense Area Rain Gauge Networks in DAD Study.

| **Depth Area Duration Study Areas** | **Data Processed** |
|---|---|
| Walnut Gulch, AZ | ✓ |
| Reynolds Creek,ID | ✓ |
| Tifton, GA | ✓ |
| Hastings, NE | ✓ |
| Alamogordo Creek, NM | |
| Safford, AZ | |
| Santa Rita, AZ | |
| Cochocton, OH | ✓ |
| Danville, VT | ✓ |
| Chicago, IL (NCDC stations) | ✓ |
| Riesel, TX | ✓ |

## 5. Issues.

### 5.1 Seasonality

We reviewed the meaning, utility and computational difficulties associated with frequency estimates computed by season. Because of the noise in the data, seasonal estimates do not combine to give annual estimates. This incongruity cannot be resolved without arbitrary limits being placed on results. We are uncomfortable with imposing arbitrary limits but at the same time are concerned about the confusion that may be caused by publishing incongruous results. Furthermore, after checking with a variety of partners we found no consensus of demand for the estimates nor a consensus on how such results would be used. Accordingly we have decided not to prepare seasonal frequency estimates.

### 5.2 Publication

Printing of the final documents is expensive and time consuming. Furthermore, we have found no reasonable way to avoid ongoing infrastructure costs of delivering and billing for the printed documents. Accordingly, we have decided to avoid both the costs and delay by publishing the documents in PDF format on the Internet.

## 6. Projected Schedule.

The following list provides a tentative schedule with completion dates. Brief descriptions of tasks being worked on next quarter are also included in this section.

Data Collection and Quality Control [complete]
L-Moment Analysis/Frequency Distribution [complete]
Temporal Distributions of Extreme Rainfall [complete]
Peer review of point estimates [July 2002]
Trend Analysis [July 2002]
Spatial Interpolation [November 2002]
Precipitation Frequency Maps [December 2002]
Final Report [December 2002]
Web Publication [December 2003]
Spatial Relations (Depth Area Duration Studies) [January 2003]

## 6.1 L-Moment Analysis/Frequency Distribution.

L-moment statistical analyses of annual maximum series are complete for all daily, hourly and n-minute data pending review comments. Partial duration series will be analyzed so that conversion factors from annual maximum series to partial duration series can be developed.

## 6.2 Trend Analysis and Seasonal Analysis.

Statistical tests have been run on the completed 24-hour dataset to test for any trends or shifts in annual maximums through time. The results of these tests are currently being compiled and analyzed. Data has been extracted to produce a seasonal analysis comparing the percentage of precipitation maximums that occur in each month of a year. These tasks will be completed in the next quarter.

## 6.3 Temporal Distributions of Extreme Rainfall.

The methodology we used for developing temporal distributions of extreme rainfall events has been validated and the documentation of the results will be completed this quarter.

## 6.4 Spatial Interpolation.

Data has been delivered to SCAS. A kickoff conference call will initiate the task in early July; implementation of project schedules and tasks will be discussed. A status meeting is tentatively scheduled in Corvalis, Oregon in late July to discuss the interpolation methodology and draft maps.

## 6.5 Peer Review.

A peer review of point precipitation frequency estimates was initiated in June, 2002. It will end on July 26, 2002, at which time HDSC will address review comments.

## 6.7 Spatial Relations (Depth Area Duration Study).

The method to be used for computing the DAD curves has been selected. Software to decode and format the data files and the DAD computations will be developed. If additional dense-area-networks are available, they will be added to our database.

## References

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